Hydrogeology of Wales: Carboniferous aquifers - groundwater quality in the South Wales Coalfield

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This page is part of a category of pages that provides an updated review of the occurrence of groundwater throughout Wales.

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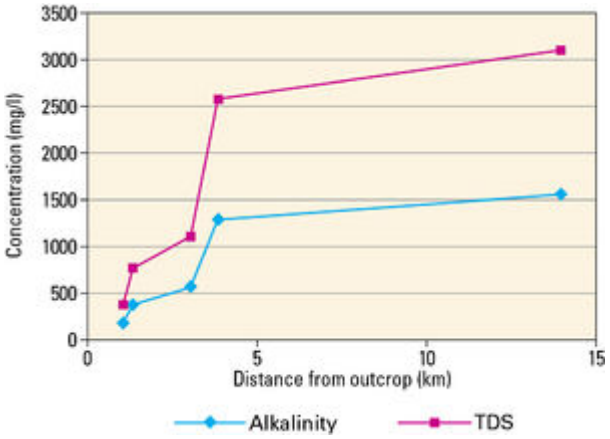
The groundwater in the South Wales Coal Measures Group is characteristically less mineralised than groundwater found in other British coalfields. Total dissolved solids are commonly <1000 mg l^{-1}, exceptionally approaching 10 000 mg l^{-1}. The more saline groundwaters tend to be of the Na-SO_4 type, whereas Na-Cl type waters are notably absent in south Wales. The South Wales Upper Coal Measures Formation is typically Ca-HCO_3 type. In the argillaceous horizons Ca and Mn rich groundwaters occur near outcrop with salinity increasing down-dip. The increase in alkalinity and total dissolved solids away from the Pennant Sandsone and Warwickshire Group outcrop down-dip through Tirpentwys, Crumlin, Celynen and Penallta collieries shows a similar increase for samples collected in the Old Coal horizon (**Figure P859275**). Ion exchange tends to create Na dominated waters (Na-HCO_3 and Na-SO_4) towards the main syncline but the availability of Na is small compared with that in major coalfields elsewhere.



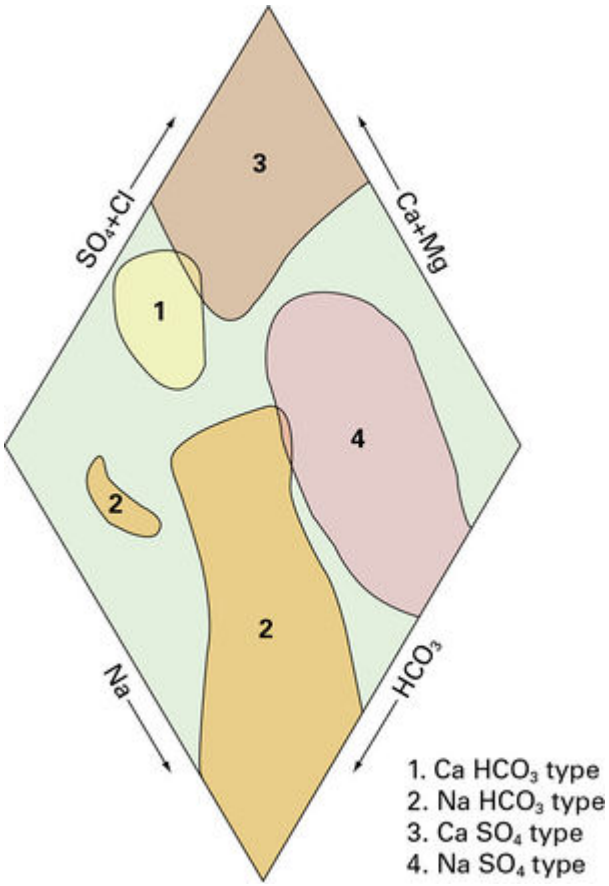
Alkalinity and total dissolved solids evolution down dip in the Old Coal Horizon (after Ineson, 1967). P859275.

Although analytical data for mine water discharges are plentiful, few of these data represent specific horizons or even groups of horizons. Most represent mixed waters draining from colliery sumps. In addition many contemporary analyses focus on acid mine drainage rather than groundwater uncontaminated with soluble products of Fe and S.

The uppermost shallow groundwater circulation which discharges locally to springs and as base flow to streams and rivers is weakly mineralised Ca-HCO_3 type groundwater with a total dissolved solids concentration typically <300 mg l^{-1}. This is a young and immature groundwater which reflects short transport pathways and relatively short transit times.

Groundwaters circulating deeper into the South Wales Coal Measures Group are more highly mineralised than the shallow groundwaters. A survey of 178 samples for the eastern part of the coalfield gathered by **Ineson (1967)** showed a high percentage of moderately mineralised discharges with little over one in eight of the samples exceeding 1000 mg l^{-1} total dissolved solids. Four types of groundwater are present (**Figure P859276**): Ca-HCO_3, Ca-SO_4, Na-HCO_3 and Na-SO_4 groundwaters. There are also isolated occurrences of Mg-HCO_3 groundwater found in Ebbw Vale. The Na-SO_4 type tends to be the most mineralised. All of these waters contrast with those typical of the coal measures facies in Scotland and England where Na-Cl groundwaters tend to prevail. A number of explanations have been put forward for the relative scarcity of the Cl ion, the most likely that any connate sea water has long been flushed from the system. This is a probable explanation which relates to the deep burial of the coal measures subsequent to deposition, so creating the anthracite beds of the western coalfield, and of subsequent uplift and exposure.

The most common groundwater type in the South Wales Upper Coal Measures Formation is Ca-HCO_3 and in the South Wales Lower and Middle Coal Measures formations is Na-HCO_3. The progression from Ca to Na dominance reflects cation exchange occurring with increasing residence time and transit down dip, starting from a relative immature and weakly mineralised groundwater and developing into the older, more mature groundwaters that are found in the South Wales Lower and Middle Coal Measures formations. There are also abundant mudstones in these deeper strata to aid the cation exchange processes. The Na-SO_4 type water is likely to represent an intermediate phase. Occurrence of Fe in solution is widespread although concentrations rarely exceed 10 mg l^{-1}.



Piper diagram showing the distribution of the four main groundwater types in the South Wales Coal Measures Group (after Ineson, 1967). P859276.

The work by **Ineson (1967)** is valuable as it can no longer be replicated. Wholesale abandonment of the coalfield has allowed mine-water rebound to occur. Rising mine waters have since taken soluble

hydrous products of pyrite into solution to produce acid sulphate-rich mine waters (identifiable at surface by the ochreous deposits that form once the discharge emerges into contact with the atmosphere).

The natural groundwater chemistry recorded as discharge to working collieries contrasts with the quality of the mine waters that have emerged at surface as acid mine drainage following coalfield closure. *Brown et al. (2002)* studied these discharges and found that they fell into two distinct groups. Those deriving from the South Wales Upper Coal Measures Formation remained as Ca-HCO_3 type, with increased salinity and reduced pH. Those from the South Wales Lower and Middle Coal Measures formations were of the Na-SO_4 type, with greatly increased salinity, anoxic, and again with low pH, but having reverted from Na-HCO_3 type to Na-SO_4 type due to the availability of soluble products of S that had formed in the previously aerobic environment of the mine workings.

Ongoing groundwater monitoring carried out by the Environment Agency concurs that the dominant groundwater type is Ca/Mg-HCO_3 with subordinate dominance of Mg and SO_4. Maximum observed concentrations of NO_3 are 22 mg l^{-1}.

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